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Quick Report for the Ledgewood-Bonair Landslide, Whidbey Island, Island County, Washington

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Summary of site conditions

The Ledgewood–Bonair Landslide (LB Landslide) on Whidbey Island, Island County, Washington occurred around 3:45 am on March 27, 2013, and is a small portion of a much larger landslide complex (Fig. 1). The larger landslide, which is approximately 1.5 miles long, is prehistoric and may date back as much as 11,000 years. The LB Landslide is likely a reactivation of a small portion of the prehistoric complex. The dimensions of the landslide are approximately 1100 feet long (measured parallel to the shoreline) and about 300 feet into Puget Sound. Initial estimations place the volume of material mobilized as great as 200,000 cubic yards (~40,000 dump truck loads).

DNR geologist Michael Polenz identified the affected slope as a prehistoric landslide in 2005, and that finding was later published as part of a geologic map of the Camano quadrangle (Polenz and others, 2009, (http://www.dnr.wa.gov/Publications/ger_gm68_geol_map_camano_24k.pdf)). Polenz's field notes from 2005 identify a large landslide complex from the top of the slope, about 200 ft above sea level, to the shore and include references to the work of Jerry Thorsen, an earlier DNR geologist, who noted episodic slide activity that affected at least one small portion of the larger landslide complex between 1981 and 1997. Thorsen noted that this landslide activity demolished a beachfront residence over a period of time from 1996 to 1997 (Fig. 2), approximately 800 feet north of the LB Landslide.

DNR's 2005 field work suggested that sediment at the top of the landslide-affected slope dates back to the most recent ice age and consists of glaciomarine sediment (ice age seafloor sediment), till (sediment deposited at the base of glacial ice), and outwash (sediment deposited by glacial meltwater). In 2005, little could be seen of the geologic deposits between the top of the slope and the base of the slope. At the base of the

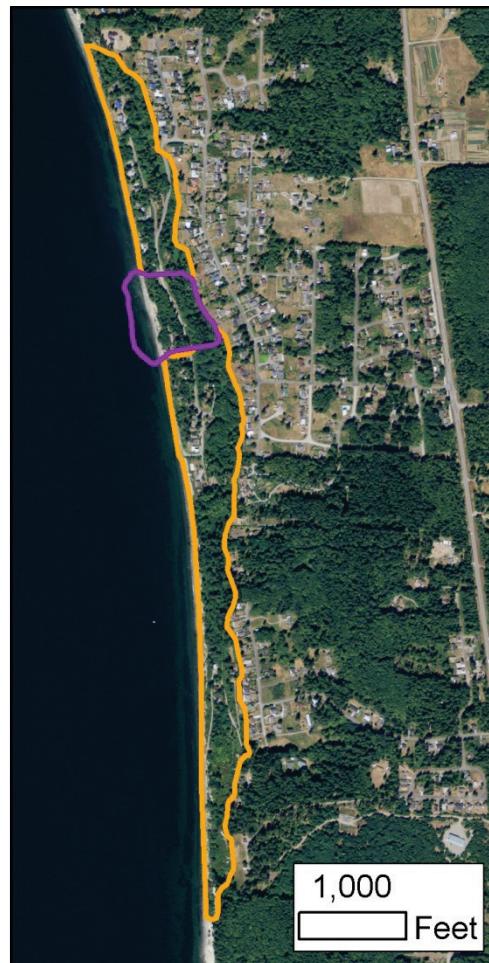


Figure 1. Reconnaissance map of the Ledgewood–Bonair Landslide. Purple outline is the approximate area of the landslide, based on reconnaissance-grade GPS, field observations, and oblique aerial imagery from news media outlets. The orange outline is the area of the prehistoric landslide most recently mapped by Polenz and others (2009).

slope, sediment was also identified as glaciomarine and included shells (identified as marine by Liz Nesbitt of the Burke Museum at the University of Washington). Radiocarbon dates from those shells, and amino-stratigraphic correlation age estimates for the same shells suggest that the sediment at the base of the slope date from an earlier glaciation. This suggests that the mid-slope sediments may include sediment from non-glacial times (like today's environment), and exposures elsewhere along the shores of Whidbey Island have revealed many non-glacial sediments from the Whidbey Formation and the Olympia non-glacial period. Polenz and others' 2009 map shows a northwest-trending strand of the southern Whidbey Island fault across the prehistoric landslide.



Figure 2. Oblique aerial image from 2001 showing a landslide that occurred in 1996–1997. The house is on the beach in the lower left corner of the photo and is located approximately 800 feet north of the Ledgewood–Bonair Landslide. Image is from the Dept. of Ecology.

Observations of the Ledgewood-Bonair Landslide on March 27, 2013

When we arrived on site in early afternoon, we started at the north side of the landslide near the intersection of S. Driftwood Way and Seaward Way. Power lines lay on the road and S. Driftwood Way ended at a 30-foot drop off onto the landslide body. We heard a tree crack and fall somewhere on the landslide body, a potential signs of landslide movement. At the beach, the toe of a deep-seated landslide failure plane uplifted the pre-existing beach as high as 30 feet above the shore (Figs. 3 and 4).

This movement suggests the deep-seated failure plane is located below sea level, and the depth is unknown at this time. Uplift of the beach is presumed to have been relatively slow (that is, over a few minutes) due to a lack of dewatering features observed on the uplifted beach (Fig. 5). The landslide occurred at approximately 3:45 am, roughly an hour before an 8.4-foot high tide. Deformation in the toe zone is extensive. Radial cracks extend perpendicular to the lobate toe, with radial cracks prevalent at the northern and southern margins of the toe. Wave and tidal action are actively eroding the toe, with small sections (1-10 cubic feet) observed calving with the rising tide. Transverse cracks parallel to the edge of the toe have deformed the uplifted beach in numerous locations, with cracks up to 35 feet long and up to 4 feet vertical displacement. A driftwood line is still evident, as well as dried seaweed from a previous high tide. GPS measurements of the toe suggest it is slightly over 1100 feet long and extends approximately 300 feet into Puget Sound.



Figure 3. Geologists Hugh Shipman (left, Dept. of Ecology) and Stephen Slaughter (right, Dept. of Natural Resources) are standing between driftwood that is approximately 30 feet above the previous beach.

The body of the landslide, as observed from a safe distance, is hummocky with jack-strawed trees (Fig. 6) throughout much of the body. Where observed, the access road has been shifted approximately 80 feet down vertically and to the west. Initial GIS analysis of the area suggests the volume of material mobilized may be as great as 200,000 cubic yards. The same GIS analysis of aerial imagery from 2002 to

2009 documented a portion of S. Driftwood Way moving at a rate approximating 1 to 3 feet per year. Hugh Shipman (Dept. of Ecology) reported that the roadway had been moving intermittently for years, and this was also reported by a geologist contracted with Island County. Our initial analysis found motion in the northern portion of the landslide body; however, no movements were apparent to the south. There is a highway warning sign indicating a landslide hazard as one drives down to S. Driftwood Way.



Figure 4. Uplifted beach on the Ledgewood–Bonair Landslide is a high as 30 feet. Note the jack-strawed fir trees in the background, a sign strongly suggestive of deep-seated movement and major disturbance of the subsurface.

The headscarp appears vertical to sub-vertical and exposes the glacial geology of the area (Figs. 7 and 8). Colluvial wedges were actively forming on the scarp as overhanging debris fell from upper portions. The top of the scarp averages 200 feet above sea level.

Exploration of the back yards of houses immediately above and adjacent to the scarp did not reveal tension cracks in yards, other than within a foot or two of the edge due to active sloughing of debris. Fence lines perpendicular to the scarp do not appear recently warped due to ground movements. Examination of building foundations, driveways, rock walls, and other structures did not reveal evident separation from the surrounding soil. Discussion with two residents revealed that neither observed any

changes in the interior of their homes, including difficultly opening doors, breaks in water lines, blocked septic systems, or obvious crack on interior walls.



Figure 5. Southern portion of the toe of the Ledgewood–Bonair Landslide. The break in the surface of the toe is interpreted as one of several radial cracks further incised by tidal and wave action.

Summary

Areas to watch for additional landslide movement would include the landslide toe and body, where wave and tidal action will erode the toe. A landslide toe can be described as a “retaining wall” for the body of the landslide. As the toe is eroded, upslope portions of the landslide body may remobilize to move the body into equilibrium. The head scarp will likely experience calving of debris for days to months as the near vertical headscarp erodes. Those who choose to return to their homes and those who live along the prehistoric landslide should watch for signs of potential landslide reaction:

- Newly developing cracks, mounds, or bulging on streets, sidewalks, or the ground in general
- Sagging or taut utility lines; leaning telephone poles, fences, or trees
- Sticking windows or doors; new and/or growing cracks in walls, ceilings, or foundations
- Broken or leaking underground or surface utilities, such as water, septic, or sewer lines
- Separation of foundation from sill plates; movement of soil away from foundation

- Changes in water well levels or cessation of well functioning
- Increase or changes in spring or seep activity; ground becoming soggy or wet



Figure 6. Body of the Ledgewood–Bonair Landslide. Jack-strawed fir trees were occasionally falling and cracking on the afternoon of March 27, 2013. Note the house on the left that was severely damaged by the landslide and pictured by most media outlets.

For more pictures, see our Flickr page link at:

<http://www.flickr.com/photos/wastatednr/sets/72157633103436975/>



Figure 7. Headscarp of the Ledgewood–Bonair Landslide. The headscarp appears vertical to sub-vertical and exposes the glacial geology of the area. Colluvial wedges were actively forming on the scarp as overhanging debris fell from upper portions of the scarp. The top of the scarp averages 200 feet above sea level.

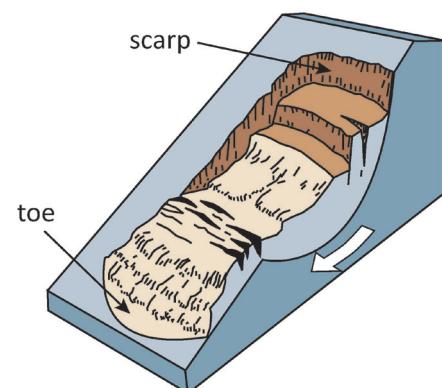


Figure 8. Diagram of a rotational landslide